Feature

Back from the brink

Against the backdrop of a global loss of biodiversity, some wildlife species have recovered from severe decimation, as a recent report shows for dozens of species in Europe. While these encouraging signs don't diminish the current crisis of species loss, the analysis of the underlying reasons — ranging from targeted conservation measures to unintended consequences of changes in human behaviour — can help researchers understand what measures may help to save other species as well. **Michael Gross** reports.

A very special birth occurred earlier this year, in early May. In the mountains of the Rothaargebirge, in central Germany, the first calf was born to a herd of Eurasian bison, which had been released only a month earlier. The new arrival, baptised Quintus, thus became the first bison to be born free in Germany for several centuries.

The small reintroduction project for Europe's largest herbivore is the brainchild of Richard Prinz zu Sayn-Wittgenstein-Berleburg, who owns some 150 square kilometres of wooded land around the small town of Bad Berleburg. He has held the herd in captivity for many years, while detailed scientific studies tried to establish whether it would be safe to remove the fences and let them roam the woods.

A path popular with walkers and mountain bikers leads straight through the nature reserve where they now roam, but visitors are unlikely to spot them in the wild, as there are only nine animals at the moment, and the area is so vast. For people who come to see bison, Sayn-Wittgenstein-Berleburg keeps a second small herd in an enclosure, the Wisent-Welt Wittgenstein (http://www.wisent-welt.de).

While the reintroduction of ancient looking megafauna in a densely populated and industrialised country like Germany may look surprising at first, it is part of a wider trend that sees wildlife making a comeback across Europe, as habitat is restored and farmers abandon economically unattractive sites.

A detailed report commissioned by the foundation Rewilding Europe (www.rewildingeurope.com) and compiled by the Zoological Society of London (ZSL), BirdLife International, and the European Bird Census Council (EBCC), lists 37 species of mammals and birds that have gained significantly in population and/or distribution since the 1950s (*Wildlife comeback in Europe: The recovery of selected mammal and bird species* http://static.zsl.org/files/wildlife-comeback-in-europe-the-recovery-of-selected-mammal-and-bird-species-2576.pdf).

Far from diminishing the urgent concerns regarding the rapid disappearance of species, the detailed case studies collected in the report should hopefully help conservation of threatened species by clarifying which factors, including both conservation measures and changes in human behaviour patterns, have helped the recovery of these European species. By establishing what works, the recovery report may also help those species that are still in decline.

Breeding bison

The European bison (*Bison bonasus*), which also graces the cover of the report, was once present throughout Europe from the Pyrenees to the southwestern parts of Russia. Due to hunting pressure and habitat loss, it became extinct in the wild in 1927. Only just over 50 animals remained in captivity, all descending from the same 12 individuals. Carefully monitored breeding programmes based on this stock provided the herds for reintroductions in several European countries. Breeding is monitored by the European Bison Pedigree Book (EBPB), the first studbook for any wild species.

The bison mostly feeds on open grasslands, but likes to withdraw into woodlands to ruminate, and also to eat smaller amounts of bark and shrubs. It is possible that this behaviour developed in response to hunting pressure from humans. In any case, areas with a mixture of open land and forests are the habitats where the bison could be reintroduced.

The first reintroduction was carried out in the Białowieża forest on the border between Poland and Belarus. This area has formed a crucial part of the species' historical range, and the

Ecological engineering: The Eurasian beaver, one of the species that have made the most dramatic recovery in the last five decades, is valued by ecologists for the opportunities its dam-building creates for other species. (©Peter Cairns/Wild Wonders of Europe and Rewilding Europe.)

Wading back: The return of the Eurasian spoonbill shows that conservation of wetland habitat and nesting sites does help species to recover after dramatic decline. (©Jari Peltomäki/Wild Wonders of Europe and Rewilding Europe.)

population is now well established on both sides of the frontier, although there are physical barriers preventing exchange between both populations.

Further populations in the wild were established in Poland, Estonia, Lithuania, Slovakia, Belarus, Romania, Ukraine and Russia. The population expanded fastest in the late 1950s and in the 1960s, when reintroduced herds established themselves. It slowed down in recent decades, but is still growing, and there is still potential for further reintroductions, as the example from Germany shows. In 2011, more than 2,700 bison lived in 33 herds across the eastern parts of Europe.

Analysing the reasons underlying the recovery of the European bison, the report finds that it is mainly down to an ambitious captive breeding and reintroduction programme. Outside these efforts, the species seems to have gained very little ground by natural expansion. As a result, many of the current populations remain small and fragmented.

For future conservation efforts, the report recommends "to focus on creating suitable habitat in areas where farmland is being abandoned, such as in the Carpathians, as well as on establishing a metapopulation across eastern Europe, on which the long-term survival of the species depends."

Spreading like beavers

The Eurasian beaver (*Castor fiber*), while not quite extinct, was reduced to a residual population of 1,200 animals in the early 20th century, surviving in five isolated watersheds, namely: Rhone (France), Elbe (Germany), Telemark (Norway), Pripet (Belarus, Ukraine, Russia) and Voronezh (Russia). It was hunted for its fur, meat, and castoreum (a secretion used for perfumes and medicines) and also suffered from the loss of wetland habitat. Helped by reintroductions, restoration of wetlands, and legal protection, it has spread remarkably in the last few decades, coming close to regaining its historic distribution.

Ecologists value the beaver for the 'engineering' work it does to its environment, which creates new opportunities for many other species, including invertebrates, amphibians and birds. As small rivers are no longer of economic importance and are often restored to a natural state in an attempt to mitigate flooding, the dam-building activity can make a positive contribution to the regeneration of river ecosystems.

Legal protection for the beaver has been introduced in various European countries since the beginning of the 20th century. Reintroductions were first carried out in 1922, when populations were translocated from Norway to Sweden. In 1927, Swedish beavers were exported to Latvia, where the species had become extinct in the 1830s. At that point, the motivation was to support the fur trade, but over time the emphasis shifted to conservation and ecosystem regeneration.

Today, the population of European beavers is estimated to exceed 300,000. Three quarters of the animals are resident in Sweden, Norway, Latvia or Lithuania. Due to its spectacular recovery, the beaver is now categorised as 'Least Concern', and there are no general threats to its survival.

Unlike the return of the bison, which was clearly driven by reintroduction, the success of the beaver has many facets that supported each other. Legal protection and hunting bans were important, as were some translocations and the regeneration of wetlands, but, given this initial help, the species regained a lot of ground by natural recolonisation.

Despite this remarkable success, the report finds that "large areas of suitable habitat remain unused, suggesting plenty of opportunity for further spread." Reintroduction efforts are continuing, for instance, in the Danube basin. The UK may also see the return of furry dam-builders, as an unofficial reintroduction seems to have succeeded in Scotland and the species may recolonise mainland Britain from there.

Summarising the findings from the case studies of mammals, the report's first author Stefanie Deinet from the ZSL comments: "The selected mammal species in our dataset have been able to come back from low numbers and small ranges because of a combination of different factors. We do see some

common themes, however, with legal protection (especially at the European level) playing a key role in the initial recovery of many species. Secondly, species-specific conservation actions addressing the underlying causes of previous declines, for example, the management of exploitation and hunting, have been very important."

Then there are the species — like the beaver — that spread easily, "gaining in number and range without direct assistance such as reintroductions," says Deinet. "This suggests that if we mitigate the major threats and give wildlife the opportunity, it may be able to bounce back almost of its own accord. Despite these successes, some species are finding it hard to continue their conquest of the European continent due to negative public opinion and conflict with local people. It is important that in these cases we focus on solving the issues through engagement with the public, tapping into traditional knowledge on how to live alongside these species, and creating economic opportunities relating to this wildlife comeback."

Set free: The comeback of the European bison is mainly due to carefully managed breeding and reintroduction programmes. (©Florian Möllers/Wild Wonders of Europe and Rewilding Europe.)

Birds come back

One of the bird species that have made a dramatic recovery is the Eurasian spoonbill (*Platalea leucorodia*). Historically, this wading bird declined mainly due to the drainage of its wetland habitat. Accordingly, legal protection of its habitat and nesting sites is seen as the main factor enabling its recovery.

The European subspecies of the spoonbill is divided into two populations with separate migration paths. The Atlantic flyway population migrates along the Atlantic coast to western parts of Africa, while the continental flyway population passes through Italy or Turkey to North Africa and the Middle East.

Population studies have shown severe losses of the continental flyway population mainly for birds breeding in Russia or Turkey. For the area covered in the report, however, recovery has been observed. Specifically, populations in Hungary and Romania are increasing, and new colonies have been established in Italy, Slovakia, and the Czech Republic.

Of the spoonbills that prefer the Atlantic route, almost half breed in the Netherlands, and the others mostly in Spain or in France. The headcount in this population more than doubled between 1991 and 2012. In the Netherlands, where the birds are monitored particularly carefully, the number of breeding pairs has gone up sevenfold since 1962.

The recovery of this species is an example of what protection of wetland habitat can achieve. Remaining dangers to the spoonbills are collisions with overhead power lines as well as illegal hunting in countries they transit on the continental route.

It used to be said that both storks and birth rates in Europe were in decline, showing that parallel statistical curves do not necessarily prove a causal effect, unless you want to believe that storks deliver babies. Now, maths teachers may have to go looking for a new example for coincidental statistics, as the storks are making a comeback.

The white stork (*Ciconia ciconia*) was in decline until the mid-1980s. One of the factors decimating its population was the lack of food in its wintering grounds in the Sahel region, which suffered prolonged drought conditions from 1968 to 1984. In addition, overgrazing and over-use of pesticides in Africa also affected its food supply.

European icon: Its popularity and iconic status across Europe means that the white stork suffers very little persecution and has been able to make a swift recovery after the food crisis in its African wintering areas. (©Mark Hamblin/Wild Wonders of Europe and Rewilding Europe.)

A recovery from this decline first became obvious in a census conducted in 1994–1995, and was confirmed in the 2004–2005 census, which estimated the population in Europe to comprise more than 200,000 breeding pairs. The majority of these breed in eastern Europe, specifically in Poland, Ukraine, and Belarus. In western parts, Spain holds the most significant stork population. Due to the large population size and wide range, the species is now classified as Least Concern.

Apart from the end of the Sahel drought and other climate factors, the recovery appears to have been driven by unintended consequences of human actions. For instance, the western stork population (Spain and France) has benefited from increased food availability due to irrigation in agriculture, open landfill sites, and the spread of an invasive crustacean species, the Louisiana crayfish (*Procambarus clarkii*). Improved food supply in Spain has led some storks to give up on the annual migration, which in turn reduces their exposure to certain risks.

Due to its iconic image in European culture, the stork has suffered very little hunting, although poaching along its migration routes can happen. Conflicts may occur when they nest on man-made structures, such as pylons, but by and large the prognosis for storks is hopeful.

Predators and people

Few people will object to the return of spoonbills and storks, but when the rewilding of European nature includes carnivores such as lynx, bear and wolf, age-old fears are reintroduced along with the species. These species have suffered a dramatic decline across Europe since the 1950s and are now very slowly and cautiously being reintroduced to suitable territories, as wild ungulate prey populations also expand and the idea gains wider acceptance.

The grey wolf, for instance, is thriving in parts of eastern Europe, particularly in the Carpathian, Balkan, and Baltic regions, where it is listed as Least Concern. Smaller populations in central and western Europe are less viable but are receiving active conservation support. Persecution by farmers is still the main threat, so the biggest task for conservation efforts is to mitigate conflicts with the human population.

Other carnivores recovering according to the report include the brown bear, the Iberian and Eurasian lynx, the wolverine, and the golden jackal. The fact that 18 mammalian and 19 avian species covered in this report have gained in population size after severe decline or even extinction in the wild does not diminish the global trend of many more species still declining or becoming extinct.

Co-author Christina Ieronymidou, from BirdLife International at Cambridge, UK, cautions not to generalise the findings of the report: “Most of the bird success stories we present in the report are for large charismatic species, which are vulnerable to direct persecution, or colonial species or species restricted to particular habitat types, such as wetlands,” she explains. “Recovery of these species followed protection from persecution, protection of key sites, such as breeding colonies, and targeted species-specific conservation actions, such as reintroductions, supplementary feeding and provision of artificial nests. By contrast, success stories are few and far between for species that are threatened by large-scale loss of habitat caused by conversion of land and the impact of agriculture, infrastructure development, forestry and fisheries.”

Ieronymidou warns that, overall, birds in Europe are still declining. “Common farmland birds, for example, have declined by 53% between 1980 and 2011, according to the Pan-European Common Bird Monitoring Scheme. In these cases, turning the fate of a species around is not as simple as banning persecution.”

There is some hope, however, as close scrutiny of these cases of species coming back from the brink should help conservationists to get a clearer picture

of which conservation measures work best, and which additional factors, including natural ones and unintentional human contributions, can also help threatened species.

Protecting and restoring habitat, such as wetlands for wading birds and rivers for beavers and many other species, clearly has had a positive effect over the last six decades, as the report shows. Legal protection from hunting and persecution also helped many of the species covered in the report.

"The case studies of wildlife comeback in this report show the results of decades of conservation efforts in Europe," says Ariel Brunner, head of policy at BirdLife Europe. "Sound legislation, such as the EU Birds and Habitats Directives, have led to better hunting regulation, species and site protection and focusing of conservation investments. They show that, with sufficient resources and appropriately targeted efforts, species can be brought back, even from the brink of extinction."

Other factors that allowed wildlife recovery include the abandonment of land that is inefficient to farm with modern methods. Similarly, the decline of heavy industries, which often turned small rivers into wastewater channels, has made space for the restoration of river habitat.

Ultimately, the most important factor may be for the people to learn to live together with the returning wildlife. "For many of us, the current population levels of these comeback species seem unprecedented — they are often the highest that we have experienced in our lifetime," says co-author Monika Böhm from the ZSL. "This may lead to some negative perceptions about these species, i.e. people may think populations are too large now, that they cause damage to property and so on. Yet some of these species are still well below their historical population sizes and are not yet viable in the long term. This makes dealing with negative perceptions and human–wildlife conflict all the more important — by turning challenges of wildlife comeback into opportunities. We humans originally hunted or persecuted these species to the brink of extinction — it is ultimately up to us if we allow wildlife to come back."

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Q & A

Keiko U. Torii

Keiko Torii was born in Tokyo, Japan and grew up in Yokohama, Japan and Scarsdale, New York. She received her BS and PhD from the University of Tsukuba, Japan. Currently she is a Professor at the Department of Biology, University of Washington (UW), Seattle, USA, holding the title of the College of Arts and Sciences Endowed Distinguished Professor of Biology since 2011. She is one of the fifteen Investigators of the Howard Hughes Medical Institute-Gordon and Betty Moore Foundation (HHMI-GBMF) since 2011. Starting in 2013, she is also one of the three Overseas Principal Investigators at the Institute of Transformative Biomolecules (ITbM) at Nagoya University, Japan. Her group studies how plant cells coordinate proliferation and differentiation during organ morphogenesis to generate beautiful, orderly patterns, using development of stomata as a model system.

Why study plants and plant development? I was always fascinated by developmental biology and could spend hours looking through a microscope. Around the time I was a college student, genetic transformation of plants became a viable technique. Shortly after, *Arabidopsis* emerged as a model to identify key developmental mutants and their causal genes. I was struck by the beauty and elegance of the ABC model proposed by Elliot Meyerowitz *et al.* and decided to pursue my postdoctoral career to study the mechanism of plant development.

Plants, of course, are the fundamental producers of our ecosystem supporting our life and sustenance. At the same time, for me plants are like 'beautiful strangers' — they are so different from us. They don't have neurons or brains, yet they cleverly sense the surrounding environment, defend themselves, and prosper. Plant (and plant–pathogen) research has provided amazing tool kits and knowledge to advance not only plant sciences and agriculture, but also biomedical research. Recent examples include the discovery of siRNAs, plant photoreceptors that

Photo courtesy of Nagoya University.

can be used to manipulate gene expression in mammalian cells, and TAL effectors for genome engineering. I am very grateful to the HHMI for recognizing the importance of plants and also to the Institute of Stem Cell and Regenerative Medicine (ISCRM) at UW for including me as a stem cell researcher of 'other systems'. As a plant developmental biologist, I am most fascinated by the question of how plant cells, constrained by the lack of cell migration, process positional cues to regulate polarity, stem cell state and differentiation within the context of multicellularity, and hope that our research will provide insights into development and regeneration for the broader field of biomedical science.

How did you decide on your current research topics? As I mentioned, I am interested in unraveling how plant cells communicate with each other during development. So, returning to my earlier work on ERECTA, a receptor-like kinase that promotes plant growth, was a natural choice when I started my tenure-track position. I must say that serendipity played a role in my research breakthroughs. My former postdoc, Elena Shpak, and I made triple loss-of-function mutants of ERECTA and its two related receptors. When we looked at the mutants under the microscope we were struck by the unexpected phenotype, stomata all over the epidermis! At that moment it was clear to me that this would be very